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(54) SOLID-STATE IMAGE PICKUP ELEMENT AND ITS MANUFACTURING METHOD

(57)Abstract:

PROBLEM TO BE SOLVED: To prevent color mixing, smear, and the like by limiting the move of a signal charge between adjacent photosensor sections.

SOLUTION: An annular intralyer insulating film 100 for surrounding a lower-layer region of each photosensor section 120 is provided at the middle layer of a semiconductor substrate 110, thus setting the position of an overflow barrier 180 deeper at the lower-layer region of each photosensor section 120, and shallower at the surrounding region. The shallow region of the overflow barrier 180 functions as a crosswise barrier 180B. For example, light obliquely entering the photosensor section 120 is subject to photoelectric conversion at a position exceeding the crosswise barrier 180B in the lower-layer direction and is swept to further lower layer of the semiconductor substrate 110, thus preventing an electric charge from moving to an adjacent pixel. Also, at the lower-layer region of each photosensor section 120, sufficient sensitivity is obtained at the deep overflow barrier 180.

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## CLAIMS

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[Claim(s)]

[Claim 1]Two or more photosensor parts which constitute an image pick-up pixel in the upper levels of a semiconductor substrate, respectively.

Overflow barrier for providing a transfer register part which transmits a signal charge accumulated in each photosensor part, and holding a signal charge of each photosensor part in a depths part of said semiconductor substrate.
Are the solid state image pickup device provided with the above, and a barrier formation position control film which controls a depth position where said overflow barrier is formed in a border area of an adjoining photosensor part in said semiconductor substrate is provided, By controlling a depth position of overflow barrier in a border area of a photosensor part by said barrier formation position control film, Transverse direction barrier which prevents movement of a signal charge between said adjoining photosensor parts in a position shallower than overflow barrier in a lower layer field of said photosensor part was provided.

[Claim 2]The solid state image pickup device according to claim 1, wherein said barrier formation position control film is an insulator layer.
[Claim 3]Said barrier formation position control film is formed in a position shallower than overflow barrier in a lower layer field of said photosensor part, The solid state image pickup device according to claim 1, wherein said transverse direction barrier is formed in a middle depth position of said barrier formation position control film and overflow barrier in a lower layer field of said photosensor part.

[Claim 4]The solid state image pickup device according to claim 1, wherein said barrier formation position control film has the thickness from a position shallower than overflow barrier in a lower layer field of said photosensor part to a deep position and said transverse direction barrier is formed in the upper layer of said barrier formation position control film.

[Claim 5]Two or more photosensor parts which constitute an image pick-up pixel in the upper levels of a semiconductor substrate, respectively.

Overflow barrier for providing a transfer register part which transmits a signal charge accumulated in each photosensor part, and holding a signal charge of each photosensor part in a depths part of said semiconductor substrate.

After forming a barrier formation position control film which is a manufacturing method of a solid state image pickup device provided with the above, and controls a depth position where said overflow barrier is formed in a border area of an adjoining photosensor part in said semiconductor substrate, By forming said overflow barrier, a depth position of overflow barrier in a border area of a photosensor part is controlled by said barrier formation position control film,

Transverse direction barrier which prevents movement of a signal charge between said adjoining photosensor parts in a position shallower than overflow barrier in a lower layer field of said photosensor part is formed.

[Claim 6]A manufacturing method of the solid state image pickup device according to claim 5, wherein said barrier formation position control film is an insulator layer.

[Claim 7]A manufacturing method of the solid state image pickup device according to claim 6 forming it by pasting the upper semiconductor substrate together after said insulator layer forms said insulator layer in the upper surface of a lower layer semiconductor substrate.

[Claim 8]A manufacturing method of the solid state image pickup device according to claim 6, wherein said insulator layer drives predetermined ion into a semiconductor substrate and forms it by heating after that.

[Claim 9]Said barrier formation position control film is formed in a position shallower than overflow barrier in a lower layer field of said photosensor part, A manufacturing method of the solid state image pickup device according to claim 5 forming said transverse direction barrier in a middle depth position of said barrier formation position control film and overflow barrier in a lower layer field of said photosensor part.

[Claim 10]A manufacturing method of the solid state image pickup device according to claim 5 forming said barrier formation position control film in thickness from a position shallower than overflow barrier in a lower layer field of said photosensor part to a deep position, and forming said transverse direction

barrier in the upper layer of said barrier formation position control film.

## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention]This invention about a solid state image pickup device which provided the overflow barrier in the lower layer of the photosensor part, and a manufacturing method for the same, It applies to the solid state image

pickup device which formed the overflow barrier in the position deep to a substrate direction especially for the improvement in sensitivity, or the solid state image pickup device which reduced the unit length of the photosensor part, and is related with an effective thing.

[0002]

[Description of the Prior Art]Before, the solid state image pickup device of structure as shown, for example in drawing 8 is known. This solid state image pickup device forms the photosensor part 20 which performs photoelectric conversion to the semiconductor substrate (N type silicon substrate) 10, and the vertical transfer register part 30 which transmits perpendicularly the signal charge accumulated in this photosensor part 20. The photosensor part 20 forms the N+ layer 24 which turns into a lower layer of the surface P+ layer 22 used as an acceptance surface with a photoelectric conversion part, are arranged by matrix form in every direction to the semiconductor substrate 10, and constitutes the image pick-up pixel, respectively. [ many ] The vertical transfer register part 30 constitutes a charge transfer section from the upper N type well layer 32 and the lower layer P type well layer 34. Between the photosensor part 20 and the vertical transfer register part 30, the read gate part which is not illustrated for reading the signal charge accumulated in the photosensor part 20 to each transfer gate of the vertical transfer register part 30 is provided.

[0003]Further, the signal charge transmitted by this vertical transfer register part 30 is horizontally transmitted by the unillustrated horizontal transfer register section, and is changed and outputted to an imaging signal via an unillustrated charge detector. Between each photosensor part 20, the channel stopping area 40 which consists of a P type layer which separates each photosensor part 20 in the direction of horizontal transfer, and prevents disclosure of a signal charge is formed. On the semiconductor substrate 10, the transfer electrode 60 of the vertical transfer register part 30 is formed via the insulator layer 50, and the light-shielding film 70 is formed in the upper layer. Light enters into the acceptance surface of the photosensor part 20 from the opening 70A formed in this light-shielding film 70. In the lower layer of the semiconductor substrate 10, in order to accumulate a constant rate of electric charges in the photosensor part 20, the overflow barrier 80 provided and shines.

[0004]And in this kind of solid state image pickup device, the method of forming the position of the overflow barrier 80 in a position deep to a substrate direction is adopted in order to aim at improvement in sensitivity of the photosensor part 20. That is, it enables it to accumulate a larger electric charge in the deep position of the semiconductor substrate 10, and enables it to correspond to the rise of light income by forming the overflow barrier 80 in a position deep to a substrate direction.

[0005]

[Problem(s) to be Solved by the Invention]However, since the signal charge of a photosensor part is accumulated in a position with a deep semiconductor substrate when the overflow barrier is formed in a position with a deep semiconductor substrate as mentioned above, it will move even to the photosensor part which the part adjoins. Hereafter, if drawing 8 explains the principle, the signal charge 90 by the light which entered aslant at the photosensor part 20 as the arrow A2 showed, for example, If the overflow barrier is shallow, photoelectric conversion will be carried out in the position beyond this overflow barrier, and it will be swept out by the pan of the semiconductor substrate 10 at a lower layer.

[0006]However, since the overflow barrier 80 is formed in the deep position of the substrate 10 on the whole as mentioned above, the signal charge 90, It is accumulated in a position a little shallower than the overflow barrier 80, without carrying out photoelectric conversion in a position a little shallower than this overflow barrier 80, and exceeding the overflow barrier 80. Therefore, as shown in arrow B-2 of drawing 8, it can also move to an adjoining pixel direction, and with the signal charge 90 which moved to this adjacent pixel, in the case of a color imaging device, what is called mixed colors occur, and some such signal charges 90 have the problem of causing image quality deterioration in it. Also

when the unit length of a photosensor part is reduced, it becomes a relation equivalent to the position of the overflow barrier having become deep relatively, mixed colors will occur, and image quality deterioration will be caused.

[0007]Then, in order to solve such a problem, it is also possible to perform the ion implantation which forms the lateral barrier by a process different from the overflow barrier mentioned above to the horizontal and vertical pixel separation part. However, in order to form the barrier which followed even the portion with a semiconductor substrate deep in this way, it is difficult to perform energy which drives in ion in several steps, and to calculate the optimal solution of placing energy and ion concentration. It was difficult for a maximum to be among the placing energies which can form the barrier of a pixel separation part, and to fully stop mixed colors etc.

[0008]Then, the purpose of this invention prevents the disclosure to the adjacent pixel of the signal charge accumulated in each photosensor part, and there is in providing a solid state image pickup device which can prevent image quality deterioration, such as mixed colors, and a manufacturing method for the same.

[0009]

[Means for Solving the Problem]Two or more photosensor parts which constitute an image pick-up pixel in the upper levels of a semiconductor substrate, respectively in order that this invention may attain said purpose, In a solid state

image pickup device which provided a transfer register part which transmits a signal charge accumulated in each photosensor part, and provided overflow barrier for holding a signal charge of each photosensor part in a depths part of said semiconductor substrate, A barrier formation position control film which controls a depth position where said overflow barrier is formed in a border area of an adjoining photosensor part in said semiconductor substrate is provided, By controlling a depth position of overflow barrier in a border area of a photosensor part by said barrier formation position control film, Transverse direction barrier which prevents movement of a signal charge between said adjoining photosensor parts in a position shallower than overflow barrier in a lower layer field of said photosensor part was provided.

[0010]Two or more photosensor parts from which this invention constitutes an image pick-up pixel in the upper levels of a semiconductor substrate, respectively, In a manufacturing method of a solid state image pickup device which provided a transfer register part which transmits a signal charge accumulated in each photosensor part, and provided overflow barrier for holding a signal charge of each photosensor part in a depths part of said semiconductor substrate, After forming a barrier formation position control film which controls a depth position where said overflow barrier is formed in a border area of an adjoining photosensor part in said semiconductor substrate, by forming said

overflow barrier, A depth position of overflow barrier in a border area of a photosensor part is controlled by said barrier formation position control film, Transverse direction barrier which prevents movement of a signal charge between said adjoining photosensor parts in a position shallower than overflow barrier in a lower layer field of said photosensor part is formed.

[0011]By controlling a depth position of overflow barrier in a border area of a photosensor part by a solid state image pickup device by this invention with a barrier formation position control film provided into a semiconductor substrate, Since transverse direction barrier which prevents movement of a signal charge between photosensor parts which adjoin a position shallower than overflow barrier in a lower layer field of a photosensor part was provided, movement of a signal charge between photosensor parts is prevented by this transverse direction barrier. Therefore, even when lower layer overflow barrier of a photosensor part is formed in a deep position for improvement in sensitivity. Mixed colors by charge transfer between photosensor parts, an alias (smear) by charge transfer from a photosensor part to a transfer register part, etc. can be prevented effectively, and it becomes possible to aim at improvement in image quality. By using an insulator layer as a barrier formation position control film, capacitance fluctuation of a transfer register part at the time of operating an electronic shutter can also be controlled, and it is effective also in reservation of

a dynamic range.

[0012]In a manufacturing method of a solid state image pickup device by this invention. By controlling a depth position of overflow barrier in a border area of a photosensor part by a barrier formation position control film provided into a semiconductor substrate, In a position shallower than overflow barrier in a lower layer field of a photosensor part. Without forming transverse direction barrier in a deep position like before, since transverse direction barrier which prevents movement of a signal charge between adjoining photosensor parts is formed, transverse direction barrier is formed easily and movement of a signal charge between photosensor parts can be prevented. Therefore, without causing complicated-ization of a manufacturing process, even when lower layer overflow barrier of a photosensor part is formed in a deep position for improvement in sensitivity, mixed colors, a smear, etc. can be prevented effectively and it becomes possible to aim at improvement in image quality. By using an insulator layer as a barrier formation position control film, capacitance fluctuation of a transfer register part at the time of operating an electronic shutter can also be controlled, and it is effective also in reservation of a dynamic range.

[0013]

[Embodiment of the Invention]Hereafter, the embodiment of a solid state image pickup device by this invention and a manufacturing method for the same is

described. although the embodiment described below is a suitable example of this invention and desirable various limitation is attached technically, the range in particular of this invention shall not be limited to these modes in the following explanation, as long as there is no statement of the purport that this invention is limited

[0014]Drawing 1 is a fragmentary sectional view showing the structure of the solid state image pickup device by a 1st embodiment of this invention. The solid state image pickup device by a 1st embodiment of this invention, In order to prevent movement of the signal charge to the above adjacent pixels, in a position shallower than the overflow barrier 180 inside the semiconductor substrate 110. By forming the annular insulator layer 100 in a layer (barrier formation position control film) which surrounds the lower layer field of each photosensor part 120, the position of the overflow barrier 180 is deeply formed shallowly in the field of the circumference in the lower layer field of each photosensor part 120. The insulator layer 100 in a layer Namely, the pixel isolation region of a solid state image pickup device (border area of each pixel), For example, the pixel isolation region located between each pixel of the direction of vertical transfer, the read gate part located between each pixel of the direction of horizontal transfer, It is provided along a vertical transfer register part, a channel stopping area, etc., the ion implantation at the time of forming the

overflow barrier 180 is checked selectively in a pixel isolation region, and the overflow barrier 180 which has the above level differences is formed.

[0015]And by forming the overflow barrier 180 which has such a level difference, For example, the signal charge 190 by the light which entered into the photosensor part 120 aslant as the arrow A1 showed, Photoelectric conversion will be carried out in the position which exceeded the field (transverse direction barrier) 180B where the overflow barrier 180 became shallow in the direction of a lower layer, and as shown in the arrow B1, it will be swept out by the pan of the semiconductor substrate 110 at a lower layer. Thereby, the signal charge 190 is discharged without moving to an adjacent pixel, and can prevent image quality deterioration, such as mixed colors, from things. That is, in this example, the field 180B where the overflow barrier 180 became shallow is the transverse direction barrier. In the lower layer field of each photosensor part 120, sufficient quantity of a signal charge can be accumulated by the field 180A where the overflow barrier 180 became deep, and it becomes possible to aim at improvement in sensitivity to increase of light income.

[0016]Hereafter, each composition of the solid state image pickup device shown in drawing 1 is explained in order. This solid state image pickup device forms the photosensor part 120 which performs photoelectric conversion to the semiconductor substrate (N type silicon substrate) 110, and the vertical transfer

register part 130 which transmits perpendicularly the signal charge accumulated in this photosensor part 120. The photosensor part 120 forms the N+ layer 124 which turns into a lower layer of the surface P+ layer 122 used as an acceptance surface with a photoelectric conversion part, is arranged by matrix form in every direction to the semiconductor substrate 110, and constitutes the image pick-up pixel, respectively. The vertical transfer register part 130 constitutes a charge transfer section from the upper N type well layer 132 and the lower layer P type well layer 134. Further, the signal charge transmitted by this vertical transfer register part 130 is horizontally transmitted by the unillustrated horizontal transfer register section, and is changed and outputted to an imaging signal via an unillustrated charge detector.

[0017]Between each photosensor part 120, the channel stopping area 140 which consists of a P type layer which separates each photosensor part 120 in the direction of horizontal transfer, and prevents disclosure of a signal charge is formed. On the semiconductor substrate 110, the transfer electrode 160 of the vertical transfer register part 130 is formed via the insulator layer 150, and the light-shielding film 170 is formed in the upper layer. Light enters into the acceptance surface of the photosensor part 120 from the opening 170A formed in this light-shielding film 170. And the insulator layer 100 in a layer mentioned above is formed in the middle lamella of the semiconductor substrate 110. The

insulator layer 100 in this layer is formed, for example of silicon oxide etc., and mentions that formation method later. In drawing 1, although the section of the insulator layer 100 in a layer is shown only in the lower layer of the vertical transfer register part 130, the insulator layer 100 in this layer surrounds the lower layer field of each photosensor part 120, and is formed in the shape of [ which crossed / annular / in all directions ] a lattice. The overflow barrier 180 mentioned above is formed in the lower layer of the semiconductor substrate 110. This overflow barrier 180 is formed of ion implantation etc. after formation of the above insulator layers 100 in a layer. And the depth into which ion is driven changes by having formed the insulator layer 100 in a layer, and it has the deep field 180A corresponding to the lower layer field of each photosensor part 120, and the shallow field 180B corresponding to the insulator layer 100 in a layer.

[0018]Next, the concrete manufacturing method of the solid state image pickup device shown in drawing 1 is explained. Drawing 2 - drawing 4 are the sectional views explaining each manufacturing process based on this manufacturing method. First, as shown in drawing 2 (A), as opposed to the semiconductor substrate 110 which formed the insulator layer 100 in a layer mentioned above in the middle lamella, boron ion (B+) is driven in and the overflow barrier 180 is formed. Under the present circumstances, in the field in which the insulator layer 100 in a layer was formed, as a result of placing of boron ion receiving

resistance by the insulator layer 100 in a layer, as shown in drawing 2 (B), the deep field 180A corresponding to the lower layer field of each photosensor part 120 and the shallow field 180B corresponding to the insulator layer 100 in a layer are formed. Next, by the same process as usual, the vertical transfer register part 130 and the channel stopping area 140 are formed in the upper layer of the semiconductor substrate 110 one by one (drawing 3 (C)), and, subsequently to the upper surface of the semiconductor substrate 110, the insulator layer 150 and the transfer electrode 160 are formed one by one (drawing 3 (D)). Then, via the insulator layer 150, the photosensor part 120 is formed in the upper layer of the semiconductor substrate 110 (drawing 4 (E)), it ranks second to it, and a layer system as shown in (drawing 4 (F)) and drawing 1 is acquired by forming the light-shielding film 170.

[0019]Next, the 1st formation method of the insulator layer 100 in a layer mentioned above is explained. Drawing 5 is a sectional view explaining each manufacturing process based on this 1st formation method. This 1st formation method is a method of pasting the semiconductor substrate of two sheets together, first, in drawing 5 (A), it patterns the photoresist 210 after the upper surface of the lower layer semiconductor substrate 110A, removes the formation area of an insulator layer by etching in drawing 5 (B), and forms the crevice 112. And as shown in drawing 5 (C), the crevice 112 forms the insulating material

100A of SiO2 etc. in the thickness buried thoroughly, whole surface etchback is carried out and the insulator layer 100 of desired thickness is formed so that it may be shown subsequently to drawing 5 (D). Then, as shown in drawing 5 (E), the semiconductor substrate 110 which formed the insulator layer 100 in a layer in the middle lamella is obtained by pasting the upper semiconductor substrate 110B together.

[0020]Next, the 2nd formation method of the insulator layer 100 in a layer mentioned above is explained. Drawing 6 is a sectional view explaining each manufacturing process based on this 2nd formation method. This 2nd formation method is the method of forming the insulator layer 100 in a layer in the middle lamella of the semiconductor substrate 110 by placing processing and heat-treatment of ion, first, in drawing 6 (A), patterns the photoresist 220 on the semiconductor substrate 110, and drives in oxygen ion (O-) from on that. In the state immediately after [ this ] devoting oneself, as shown in drawing 6 (B), the oxygen ion field 230 is in the state where it spread in the direction of a plate surface and board thickness direction of the semiconductor substrate 110, but. By heat-treating at an elevated temperature, as shown in drawing 6 (C), oxygen ion moves to the field where concentration is high, and after heating is formed as the insulator layer 100 in a layer like a graphic display.

[0021]Next, a 2nd embodiment of this invention is described. Drawing 7 is a

fragmentary sectional view showing the structure of the solid state image pickup device by a 2nd embodiment of this invention. Identical codes are attached and explained about drawing 1 and common composition. This solid state image pickup device extends the method by a 1st embodiment mentioned above, and like a graphic display, The insulator layer 100B in a layer (barrier formation position control film) which has the thickness from a position shallower than the overflow barrier 240 in the lower layer field of the photosensor part 120 to a deep position is formed, and the transverse direction barrier 250 is formed in the upper layer of the insulator layer 100B in this layer. Namely, while enlarging thickness of the insulator layer 100B in a layer, forming in the state of surrounding the overflow barrier 240 in the lower layer field of the photosensor part 120 and separating between each pixel electrically in this example, The transverse direction barrier 250 separated into the upper layer of the insulator layer 100B in this layer from the overflow barrier 240 is formed.

[0022]After formation of the overflow barrier 240, by growing an N type board epitaxially further, especially this example is effective, when forming the overflow barrier 240 in a deeper position. And the transverse direction barrier 250 is formed between the insulator layer 100B in a layer, and a substrate face and the transfer register part 130 by driving in partial ion after the substrate formation by this epitaxial growth. It compares, when forming the transverse direction barrier

in the conventional deep position in this method, Control of ion implantation work, etc. can be performed easily and the advantage which is not in the former can be acquired from what is necessary being just to form the shallow transverse direction barrier 250, and the formation position of the barrier being controlled by the insulator layer 100B in a layer.

[0023]In each above embodiment, from having provided the insulator layer between the transfer register part of a signal charge, and the lower layer substrate as a barrier formation position control film. In addition to the effect of preventing the mixed colors mentioned above, a smear, etc., the capacitance fluctuation of the transfer register part at the time of operating an electronic shutter can also be controlled, and it is effective also in reservation of a dynamic range.

[0024]

[Effect of the Invention]As explained above, in the solid state image pickup device of this invention. By controlling the depth position of the overflow barrier in the border area of a photosensor part by the barrier formation position control film provided into the semiconductor substrate, The transverse direction barrier which prevents movement of the signal charge between the photosensor parts which adjoin a position shallower than the overflow barrier in the lower layer field of a photosensor part was provided. Therefore, the smear which can prevent

mixed colors effectively since movement of the signal charge between photosensor parts can be prevented by this transverse direction barrier, and is generated via the deep portion of a photosensor part can be prevented effectively, and improvement in image quality can be aimed at.

[0025]In the manufacturing method of the solid state image pickup device by this invention. By controlling the depth position of the overflow barrier in the border area of a photosensor part by the barrier formation position control film provided into the semiconductor substrate, The transverse direction barrier which prevents movement of the signal charge between the photosensor parts which adjoin a position shallower than the overflow barrier in the lower layer field of a photosensor part was formed. Therefore, without causing complicated-ization of a manufacturing process, since the transverse direction barrier is formed easily and movement of the signal charge between photosensor parts can be prevented, without forming the transverse direction barrier in a deep position like before, mixed colors and a smear can be prevented effectively and improvement in image quality can be aimed at.

## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1]It is a fragmentary sectional view showing the structure of the solid state image pickup device by a 1st embodiment of this invention.

[Drawing 2]It is a sectional view showing the manufacturing process of the solid state image pickup device shown in drawing 1.

[Drawing 3]It is a sectional view showing the manufacturing process of the solid state image pickup device shown in drawing 1.

[Drawing 4]It is a sectional view showing the manufacturing process of the solid state image pickup device shown in drawing 1.

[Drawing 5]It is a sectional view showing the 1st formation process of the insulator layer in a layer for the barrier formation position control in the solid state image pickup device shown in drawing 1.

[Drawing 6]It is a sectional view showing the 2nd formation process of the insulator layer in a layer for the barrier formation position control in the solid state image pickup device shown in drawing 1.

[Drawing 7]It is a fragmentary sectional view showing the structure of the solid state image pickup device by a 2nd embodiment of this invention.

[Drawing 8]It is a fragmentary sectional view showing the structure of the conventional solid state image pickup device.

[Description of Notations]

100 .... The insulator layer in a layer, 110 .... A semiconductor substrate, 120 .... Photosensor part, 122 .... A surface P+ layer, 124 .... N+ layer, 130 .... Vertical transfer register part, 132 [ .... An insulator layer, 160 / .... A transfer electrode, 170 / .... A light-shielding film, 170A / .... An opening, 180 180A, 240 / .... The overflow barrier, 180B, 250 / .... Transverse direction barrier ] .... An N type well layer, 134 .... P type well layer, 140 .... A channel stopping area, 150